PATENT SPECIFICATION (11) 1 586 260

1 586 260

(21) Application No. 54068/77 (22) Filed 29 Dec. 1977 (19)
(31) Convention Application No. 2 659 638
(32) Filed 30 Dec. 1976 in
(33) Fed. Rep. of Germany (DE)
(44) Complete Specification published 18 March 1981
(51) INT. CL.[3] H04Q 7/04 H04B 7/24
(52) Index at acceptance
H4K YR
H4L DEZ

(54) A RADIO TELECOMMUNICATIONS SYSTEM

(72) We, SIEMENS AKTIENGESELLSCHAFT, a German Company, of Berlin and Munich, Federal Republic of Germany,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a radio telecommunications system for connecting stationary subscriber stations to a telecommunications network such as a public telephone network.

A radio system of this type is disclosed by the magazine "Telephonie", September 22, 1975, pages 40 to 47. It serves to enable connection of thinly populated, relatively inaccessible areas to the public telephone network, to provide telephone links to stationary subscribers for whom the outlay of a cable connection is not viable. A radio concentrator, assigned to a dial-operated exchange, is connected to the stationary subscribers via an omnidirectional antenna. The known system operates with full duplex and makes available a common set of eight frequency-channels to the subscriber stations in all transmission directions. A channel is seized as and when required via an information exchange signal with the radio concentrator. Dynamic frequency allocation dependent on the instantaneous traffic intensity and geographical position of the subscriber station enables a substantial improvement in frequency-channel utilization in comparison to a fixed allocation of frequency-channels to the subscriber stations, as it enables considerably more subscriber stations to cooperate with a radio concentrator than there are frequency channels available for use by the radio concentrator.

In view of the fact that the substantial frequency bands for radio telecommunication are largely allocated to the public and private ground radio systems, even the improved frequency-channel utilisation of the conventional radio system mentioned above is not sufficient to connect the desired number of stationary subscribers by radio to the public telephone network, even though in rural areas the costs for subscriber connection lines and cables often substantially exceeds the cost of a radio device.

According to the invention there is provided a radio telecommunications system for connecting geographically fixed subscriber stations to a telecommunications network, for example, a public telephone network, said radio system including a geographically fixed radio concentrator which can be operatively associated with a dial-operated exchange of said network, the radio concentrator having a predetermined geographical range within which lie the fixed subscriber stations, the concentrator comprising a plurality of geographically adjacent radio subconcentrators respectively assigned to, and providing a common focus for, sectors of said range, each sub-concentrator having a directional antenna arranged to determine the position and size of the assigned range sector so as to provide a transmission link with the associated set of the subscriber stations, at least some of the range sectors being arranged to be mutually decoupled sufficiently as to be capable of allocating the same frequency-channel range to their respective associated sets of subscriptions.

It is advantageous if digital signal transmission, particularly binary digital signal transmission, is used. The like-channel power level spacing required for interference-free operation amounts to approx. 6dB when digital binary modulation is employed, so that the required angular spatial decoupling between adjoining range sectors can be achieved using simple directional radio antennae, for example YAGI-antennae employed for commercial television reception. Furthermore, digital signal transmission has the great advantage that digital signals can be readily coded to maintain secrecy of communication where the transmission links of radio telephone systems are readily acessible to eavsdroppers.

The multiplication factor, representative of the simultaneous use of the same frequency use of the same frequency-channel with-

in a radio concentrator, is proportional to the number of range sectors. With a heavy traffic concentration, it is thus advisable to select the range sectors to be as narrow as possible. In order, in this case, to limit the demands on the directional characteristics of the directional radio antennae of the radio sub-concentrators—assuming like frequency-channel ranges for all the radio sub-concentrators—it is effective to provide polarisation decoupling to improve on the decoupling between directly adjacent sectors provided by the directional antennae.

In a further embodiment spatially alternative range sectors are arranged to have the same frequency-channel range, spatially adjacent range sectors having different frequency-channel ranges.

Advantageously, in each range sector, the subscriber stations are arranged to have substantially the same received signal power level at the associated sub-concentrator antenna.

When a relatively small number of subscriber stations are located in a range sector, information exchange between a subscriber station and the radio concentrator can be carried out in the manner conventional in mobile radio systems via the free operating channel made available to the subscriber station by the radio concentrator.

On the other hand, when a large number of subscribers exist, it is advisable to provide a service channel between the subscriber stations and the radio concentrator and which is common to all the radio subconcentrators and which employs a poly-directional antenna for information exchange signals such as dialling, ringing and channel allocation. Here, when not engaged in connections the subscriber stations are arranged for the reception of the service channel signals.

If, in this case, the radio sub-concentrators associated with directly adjacent sectors, operate with different polarisation, it is necessary to arrange the polydirectional antenna for the service channel to transmit and receive the different signal polarisations.

Embodiments of this invention will now be described, by way of example, with reference to the accompanying drawings wherein:—

Fig. 1 is a polar diagram illustrating the radio range of a radio concentrator having four range sectors of a system embodying the invention;

Fig. 2 is a polar diagram illustrating the radio range with eight sectors of a second system embodying the invention,

Fig. 3 is a polar diagram illustrating the radio range of a third system embodying the invention,

Fig. 4 is a block circuit diagram of a radio concentrator of a further system embodying the invention, and

Fig. 5 is a block circuit diagram of a radio concentrator of yet another system embodying the invention.

Referring to Fig. 1, a radio telecommunications system has a radio concentrator whose radio range is divided into four sectors S1, S2, S3 and S4, by providing four radio sub-concentrators not illustrated in detail in Fig. 1. Directional antennae AS1, AS2, AS3 and AS4 are indicated merely by arrows and are mutually angularly displaced by 90° in the horizontal plane in respect of their main beam axes. Each radio sub-concentrator makes available the same set of n frequency-channels F1 . . . Fn to the subscriber stations located in the associated sector. The frequency-channels F1 . . . Fn are identical for all four radio sub-concentrators. However, in order to enhance decoupling between the range sectors different polarisation is employed in the sectors directly adjacent to one another, and in fact transmission and reception is carried out with vertical linear polarisation in the sectors S1 and S3 and with horizontal linear polarisation in the sectors S2 and S4.

The directional antennae AS1 . . . AS4 of the four radio sub-concentrators can—as already mentioned—comprise conventional YAGI-television antennae having a beam opening angle of approimately 90°, a gain of approximately 7 dB and a reflected wave attenuation of approximately 22dB. When a conventional YAGI antenna is rotated by 90° about its rod axis relative to another such antenna, a polarisation decoupling of 20 to 30 dB can readily be achieved between the range sectors of the two antennae.

The primary function of the polarisation decoupling provided in the embodiment shown in Fig. 1 is to differenciate between subscriber stations lying in the boundary areas between adjacent sectors, by means of the polarisation, with a clearly defined assignment of the subscriber stations to the one or other of the range sectors. If, on account of geographical factors, no subscriber stations lie in boundary areas between adjacent sectors, polarisation decoupling of this kind can be omitted. This applies in particular when digital signal transmission, (in particular, by binary frequency modulation) is being used, as in this case the requisite decoupling between sectors employing the same radio frequency-channels need only amount to approximately 6 dB for interference-free operation.

The radio range illustrated in Fig. 2 differs from the structure shown in Fig. 1, in, that in place of four range sectors, eight sectors S1[1], S2[1] . . . S8[1] are used. Accordingly, this radio concentrator comprises eight radio sub-concentrators having direc-

tional antennae AS^1, $AS2^1$ . . . $AS8^1$ angularly displaced by 45° from one another in the horizontal plane. Here again, the outlay for the directional antennae is kept within limits. The beam opening angle with 3 dB drop here is approximately 45°. The gain amounts to approximately 10 dB and the reflected wave attenuation to approximately 28 dB. The polarisation decoupling corresponds to that obtained in the embodiments illustrated in Fig. 1.

In the modified form of the Fig. 2 embodiment which is shown in Fig. 3, in addition to the angular decoupling, a frequency decoupling is employed between adjacent range sectors in that the set of frequency-channels F1 . . . Fn is employed in the sectors $S2^1$, $S4^1$, $S6^1$ and $S8^1$, and the set of frequency-channels Fn+1 . . . Fm are employed in the sectors $S1^1$, $S3^1$, $S5^1$ and $S7^1$. However, the radio range shown in Fig. 3 is employed only when the requirements of frequency economy allow.

The economy in frequency utilisation which can be achieved by means of systems embodying the invention will be indicated in the following by means of a calculation relating to the division of a radio range into eight sectors in accordance with Fig. 2.

It will be assumed that delta modulation with 32 kbit/s per channel is employed for the digital signal transmission, and in fact binary frequency modulation is to be employed. With the described type of modulation, the channel raster for the radio frequency-channels can be fixed for a raster spacing of 50 kHz, and will be assumed to have an overall bandwidth of 1MHz. Accordingly the number of available RF channels amounts to.

1 MHz (50 KHz.2) = 10 duplex channels. when signal transmission in full duplex operation is provided between the radio concentrator and the subscriber stations.

Thus, the effective number of channels which can be provided in the dial-operated exchange area, with eight range sectors, amounts to

10 . 8=80 channels.

Assuming dynamic frequency allocation, the number of subscribers who can be connected in the dial-operated exchange area with 0.8 connections/radio channel and 0.05 connections/subscriber is

80.0 . 8/0 . 05 = 1280 subscribers.

If it is further assumed that the area of the West German Republic contains approximately 2000 dial-operated exchanges, the total number of subscriber stations which can be connected is

1280 . 2000 = 2 560 000.

In practice the subscriber stations will not be distributed as uniformly as has been assumed for the calculation purposes. Furthermore, certain deductions must also be made for the like-channel disturbances between different dial-operated exchanges. However, even taking into consideration these limitations, the frequency economy which can be achieved is such that—at any rate considered from the available frequency aspect—there is almost no limit to the number of subscriber stations that can be connected.

The block circuit diagram in Fig. 4 illustrates a radio concentrator which consists of four radio sub-concentrators 1, 2, 3 and 4 having four directional antennae AS1, AS2, AS3 and AS4 angularly displaced from one another by 90° in the horizontal plane, and which produce a radio range as shown in Fig. 1, having four range sectors S1, S2, S3 and S4.

The different polarisations of the directional antennae AS1, AS3 on the one hand and AS2 and AS4 on the other hand is achieved by arranging that the director rods of the directional antennae AS1 and AS3 are aligned at right angles to the ground, whereas the director rods of the antennae AS1 and AS4 are arranged in the horizontal plane. At the antennae side, each of the radio sub-concentrators possesses an antenna branching device AW which is connected to radio equipment S/E for providing the frequency-channels made available by the radio sub-concentrator. The transmitting-receiving devices of the radio equipment S/E are further connected to a concentrator K which at its output is provided with a number of subscriber lines corresponding to the number of subscriber stations in the relevant range sector. Furthermore, the concentrator K is connected at its output side to a translator U, the function of which will be explained below.

The translator U is connected to distributor switching panel VD of dial-operated exchange WV. The distributor switching panel VD is divided into a connection panel for radio subscribers and a connection panel AS-TL for line subscribers. The terminals are in each case permanently wired, so that each subscriber station is clearly assigned within the dial-operated exchange WV to one of the four sections.

In the event of a call arriving at the dial-operated exchange WV for a subscriber station which can be reached by radio, this call is converted in the translator U into a selective call assigned to this subscriber station and transmitted via the concentrator K and a free frequency-channel to the subscriber station. The subscriber station receives this call by constantly interrogating the channels of the radio sub-concentrator to which it is assigned and acknowledges this call in the opposite direction via a free channel with which it has been provided by the radio sub-concentrator, and thus triggers the switch-

through of the prepared connection in the dial-operated exchange WV. In the opposite direction, the function of the translator U is to identify the subscriber station for the purpose of charge metering.

This decentralised organisation, in which the information exchange is carried out via a free RF operating channel between the subscriber station and the radio sub-concentrator and dial-operated exchange to which the radio concentrator is assigned, is effective only as long as the number of channels made available by the radio sub-concentrator is small. Otherwise the time required for the interrogation of the individual channels by the subscriber stations prior to connection establishment is too high.

Fig. 5 illustrates a variant of the embodiment shown in Fig. 4, and comprises a radio concentrator having a dial-operated exchange arranged such that the information exchange between the subscriber stations and the radio concentrator which is required for connection establishment is effected via a service channel which is common to all the radio sub-concentrators and which, in contrast to the channels associated with the radio sub-concentrators, is transmitted and received by the radio concentrator via a polydirectional (omnidirectional) antenna RA. The service channel itself possesses a radio set S/E which includes a transmitting-receiving device and which in turn co-operates with the translators U^1 of the radio sub-concentrators 1, 2, 3 and 4 via radio control device FS. Here the basic function of the translators U^1 is called analysis, whether this call be incoming in the direction towards an associated subscriber station or vice versa. When not engaged in a call, the subscriber stations within the overall radio range are switched to the service channel and constantly interrogate the latter in respect of a call which they may be receiving. A call transmitted from a subscriber station is also fed via the service channel, which is expediently a duplex channel, to the radio concentrator and passes via the radio control device FS and the translator U^1 to the dial-operated exchange which establishes the desired connection in association with the radio sub-concentrator assigned to the relevant subscriber station.

In the embodiments described above, the division of the radio range into sectors with mutual decoupling, at least in the form of an angular spatial decoupling, allows a multiple exploitation of the available frequency channels and consequently a multiplication of the number of subscribers who can be connected to a radio concentrator. This is of particular importance where a dynamic frequency-channel allocation is employed to be dependent on traffic intensity and geographical location of the subscriber stations. However, even when, in very thinly populated areas, dynamic frequency-channel allocation is not used for financial reasons, the multiple use of frequency-channels has considerable advantages in comparison to known radio systems.

One further step which can be taken to improve the mutual decoupling between adjacent radio range sectors is to arrange that the subscriber stations shall determine their transmitting power levels so that their signal levels at their associated radio concentrator shall be approximately the same.

WHAT WE CLAIM IS:—

1. A radio telecommunications system for connecting geographically fixed subscriber stations to a telecommunications network, for example, a public telephone network, said radio system including a geographically fixed radio concentrator which can be operatively associated with a dial-operated exchange of said network, the radio concentrator having a predetermined geographical range within which lie the fixed subscriber stations, the concentrator comprising a plurality of geographically adjacent radio sub-concentrators respectively assigned to, and providing a common factor for, sectors of said range, each sub-concentrator having a directional antenna arranged to determine the position and size of the assigned range sector so as to provide a transmission link with an associated set of the subscriber stations, at least some of the range sectors being arranged to be mutually decoupled sufficiently as to be capable of allocating the same frequency-channel range to their respective associated sets of subscriber stations.

2. A system according to Claim 1 wherein means are provided for mutually decoupling spatially adjacent range sectors.

3. A system according to Claim 2 wherein the antennae are arranged to provide mutual decoupling between spatially adjacent range sectors on the basis of signal power level.

4. A system according to Claim 3 wherein each range sector is arranged to use digital signal transmission.

5. A system according to Claim 4 wherein said digital signal transmission is a binary signal transmission.

6. A system according to any one of Claims 2 to 5 wherein all the range sectors have the same frequency-channel range for allocation to their respective associated sets of subscriber stations.

7. A system according to Claim 6 wherein said decoupling means includes arranging the spatially adjacent range sectors to have different polarisation transmission links.

8. A system according to any one of Claims 1 to 5 wherein spatially alternate

range sectors are arranged to have the same frequency-channel range, spatially adjacent range sectors having different frequency-channel ranges.

9. A system according to any one of the preceding Claims wherein, in each range sector, the subscriber stations are arranged to establish substantially the same received signal power level at the associated sub-concentrator antenna.

10 A system according to any one of the preceding Claims wherein a service channel is provided common to all the sub-concentrators so as to supply service signals to all the subscriber stations, the service channel having a polydirectional antenna arranged to transmit and receive over all the range sectors, the subscriber stations each being arranged to receive the service channel when the subscriber station is not engaged in a connection with another subscriber station.

11. A system according to Claim 10 wherein said polydirectional antenna is capable of transmitting and receiving radio waves of different polarisations.

12. A system according to any one of the preceding Claims wherein the frequency channel allocation within the range sectors is dynamic and dependent on the instantaneous traffic intensity.

13. A radio telecommunications system for connecting geographically fixed subscriber stations to a telecommunications network, for example, a public telephone network, said system having at least one geographically fixed radio concentrator which, in respect of organisation, is assigned to a dial-operated exchange of the communications network, the radio range of the radio concentrator, with the fixed subscriber stations located therein, being divided into radio direction sectors having a common focus at the radio concentrator and, each of which is assigned a radio sub-concentrator of the radio concentrator with a directional antenna which establishes the associated radio direction sector in respect of position and sector angle size. Those radio sub-concentrators whose radio direction sectors possess an adequate mutual decoupling, having identical frequency-channels for allocation to the subscriber stations.

14. A radio telecommunications system for connecting stationary subscriber stations to a telecommunications network such as a public telephone network, said system being substantially as described herein with reference to any one of the figures of the accompanying drawings.

For the Applicants,
G. F. REDFERN & CO.,
Marlborough Lodge,
14 Farncombe Road,
Worthing, West Sussex.
BN11 2BT.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1981.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

1586260 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1

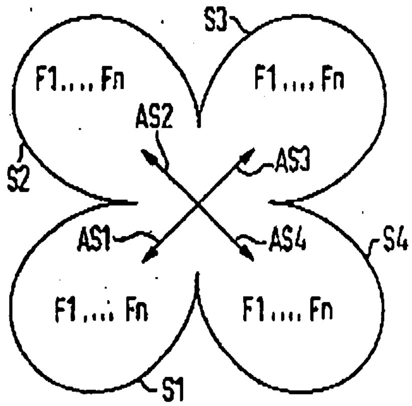


Fig.2

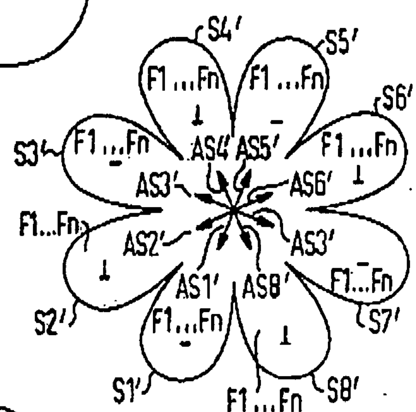
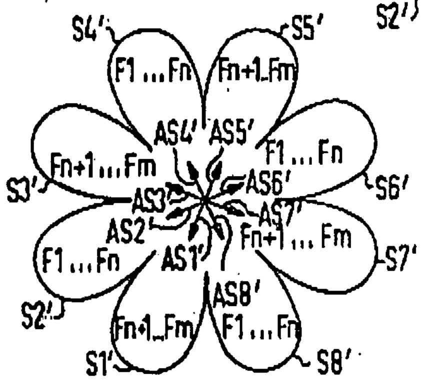
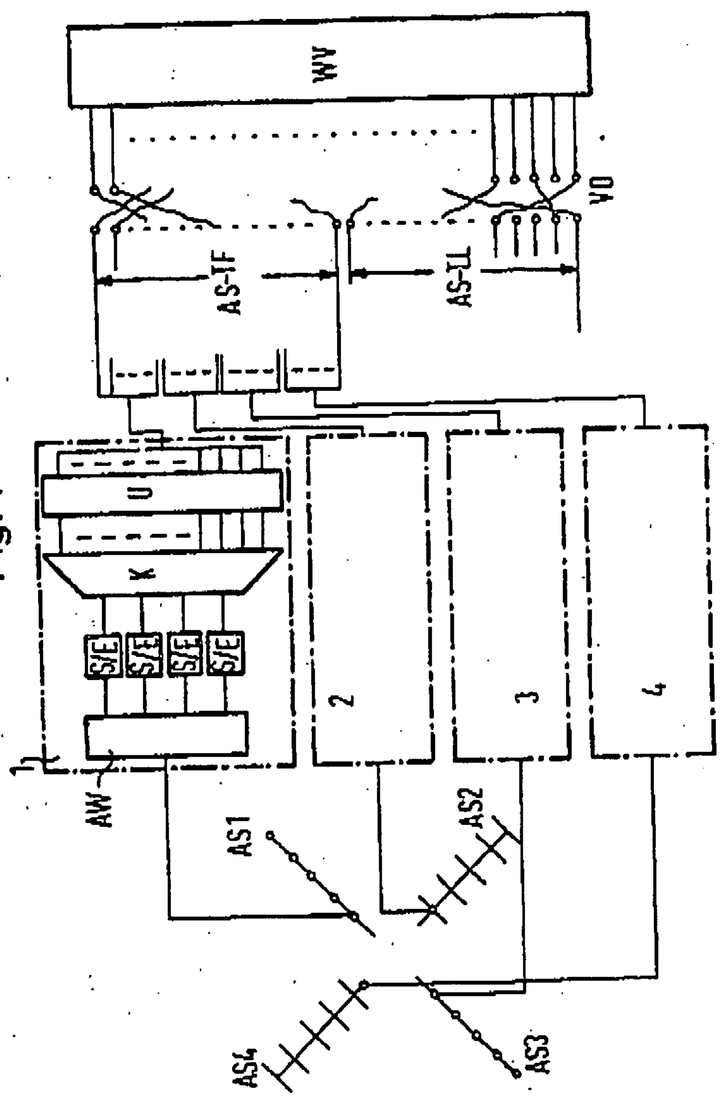


Fig.3



OIPE IAP38
APR 2 1 2006
PATENT & TRADEMARK OFFICE

Fig. 4



OIPE
APR 2 1 2006
IAP38
PATENT & TRADEMARK OFFICE

Fig.5